PSPG Renewables, May 2012

Solar Power Plants from ABB

We make Solar Power reliable and affordable

ABB Renewables
Solar Power Plants
Andres Kronenberg

ABB offers turn key solar power plants
Reliable execution and guaranteed performance

CSP power plants

- Cost effective direct steam generation
- High efficient power generation with steam parameters up to 130 bar, 530°C steam
- Highest yield per m^2 land
- In cooperation with Novatec Solar

CPV power plants

- Outstanding solar electrical efficiency with triple junction cell and dual axis tracking.
- Prefabricated and tested modular plug and play system
- In cooperation with Greenvolts

PV power plants

- Optimized integrated solution
- Maximum yield at each moment of day
- Integration into grid
- Independent from module supplier

Three solar technologies for different applications
Highest performance for every environment

CSP power plants

- Utility scale power plant from 50 MW to 250 MW
- Dispatchable energy from plant with thermal storage
- Process heat / steam
- Solar resource: high DNI area

CPV power plants

- Utility scale power plant 1 to 50 MW
- Dezentralized power plants from 100 kW
- Solar resource: high DNI area

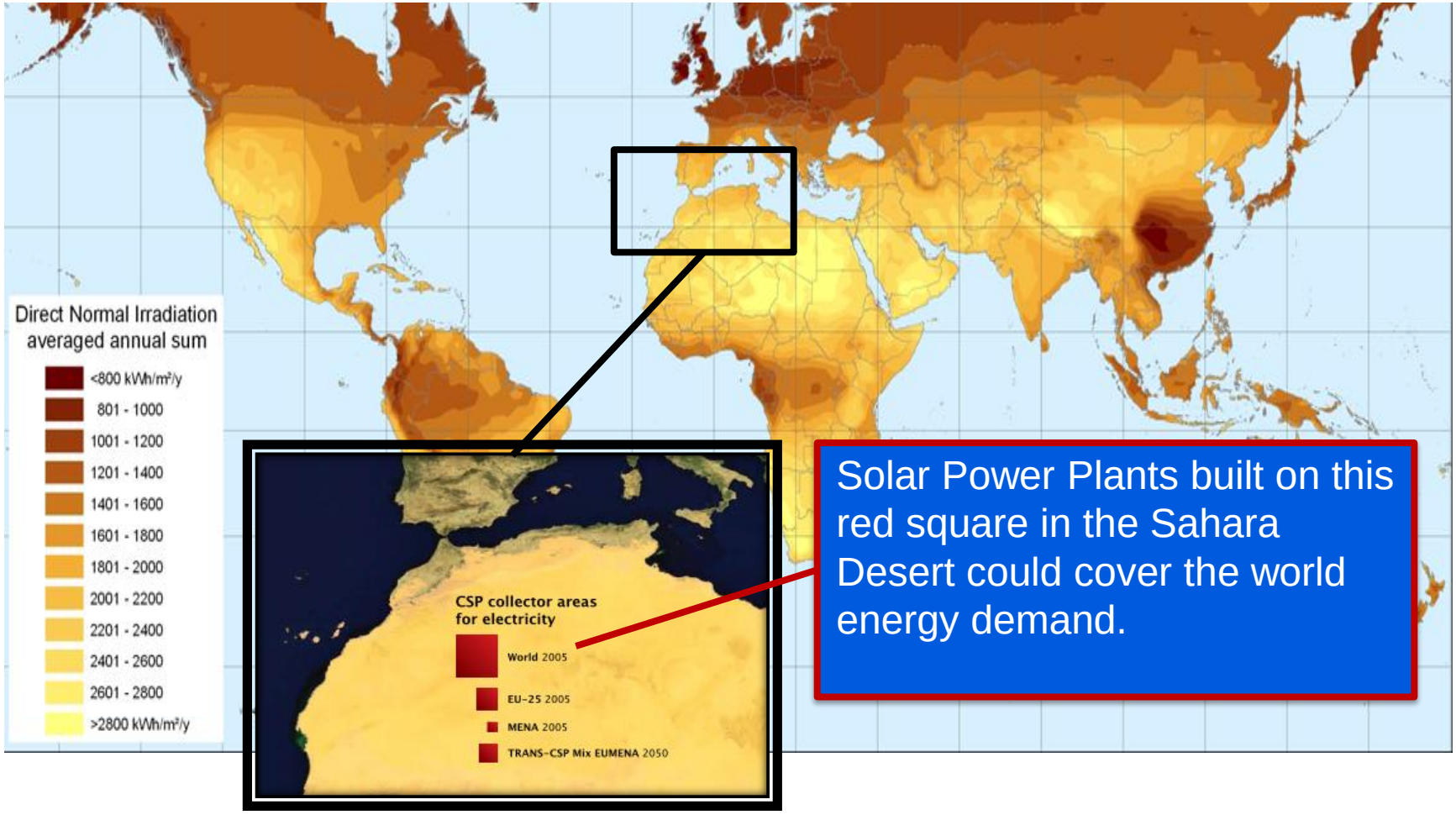
PV power plants

- Utility scale power plant 1 to 100 MW
- Industrial roof top installation from 500 kW
- Solar resource: all level of global irradiation

DNI: Direct Normal Irradiation

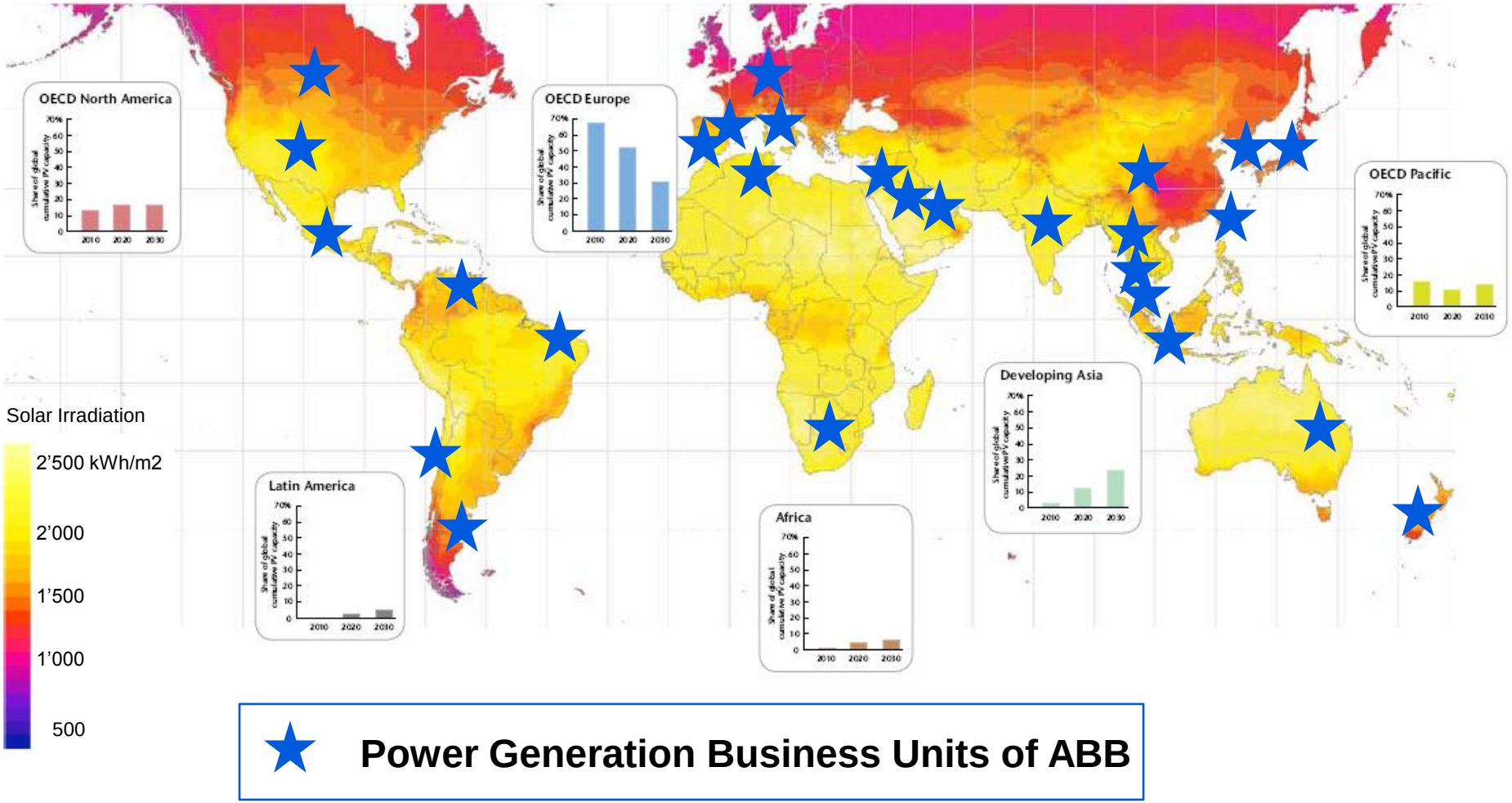
Solar resource is abundant

Within 6 hours deserts receive more energy from the sun than humankind consumes in a year. «Dr. Gerhard Knies, Desertec»



Solar Power Plants built on this red square in the Sahara Desert could cover the world energy demand.

Solar power plants for the solarbelt of the world
ABB's global footprint covers relevant solar markets

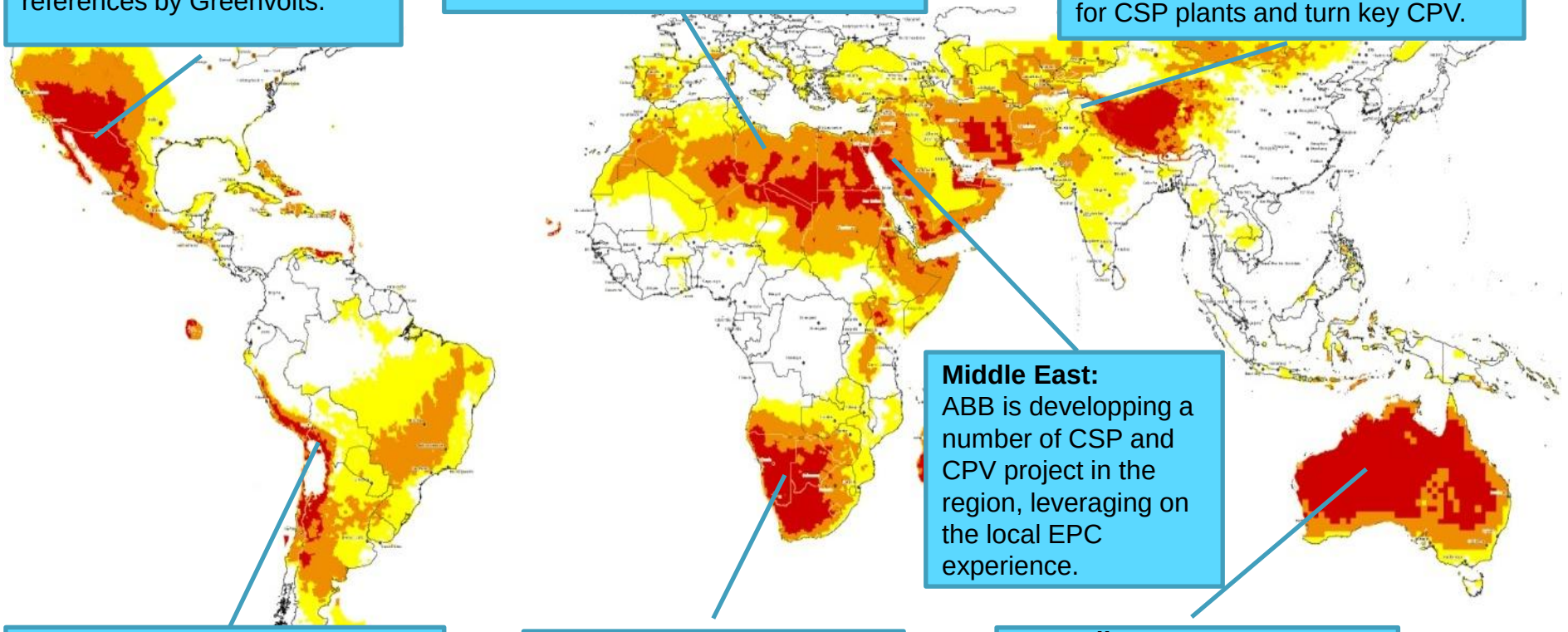


The High DNI Areas of the World
Highest Yield with CSP and CPV

SW USA:
Excellent conditions for CPV and CSP. Many CPV references by Greenvolts.

North Africa and Medditerane:
CSP references built in Spain by Novatec. Further development with focus on Northafrica.

India:
First CSP plant by Novatec about to start execution.
ABB/Novatec offer the Solar Boiler for CSP plants and turn key CPV.



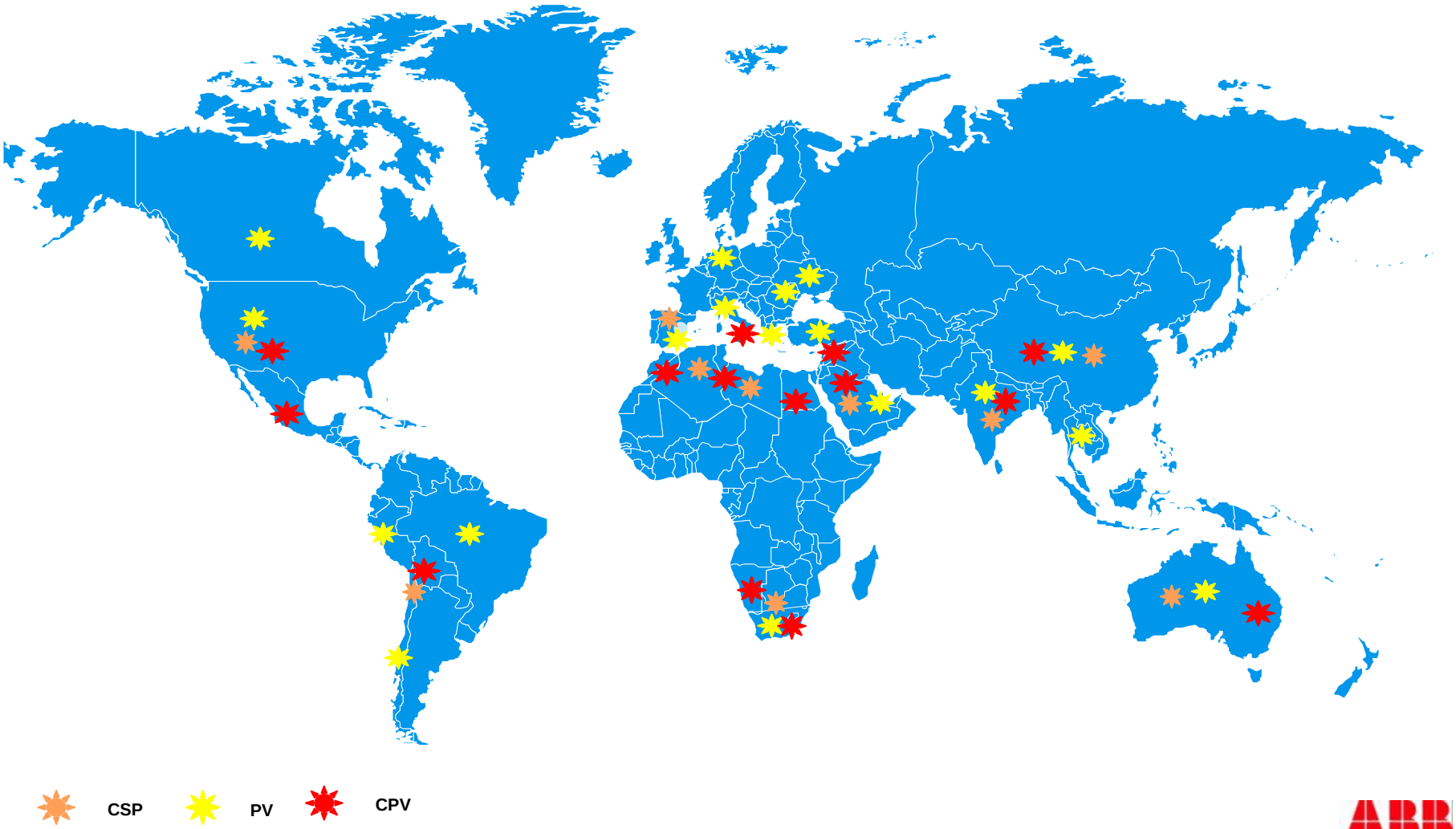
Middle East:
ABB is developping a number of CSP and CPV project in the region, leveraging on the local EPC experience.

Chile:
Excellent solar resources in remote areas.
Focus on remote operations such as mining and offer solar process heat and solar electricity.

South Africa:
ABB has delivered the first utility PV plant .
ABB is developing a number of utility PV, CPV and CSP plants.

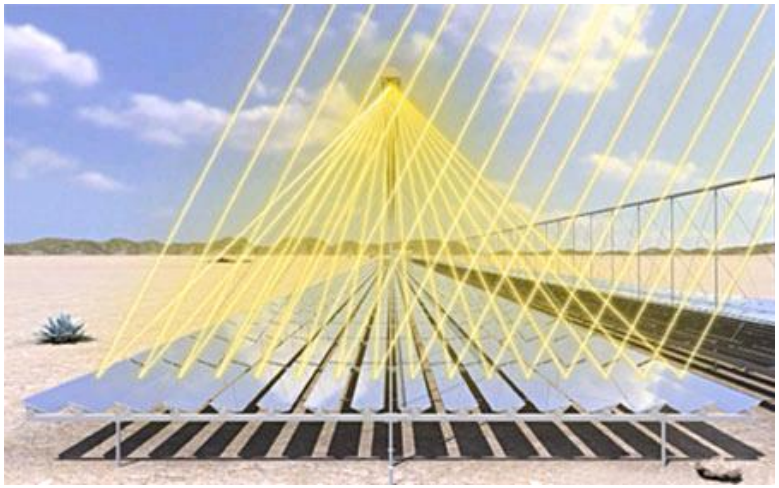
Australia:
ABB is well positioned with its subsidiary Powercorp who is specialized in the integration of solar resources into islands grids.

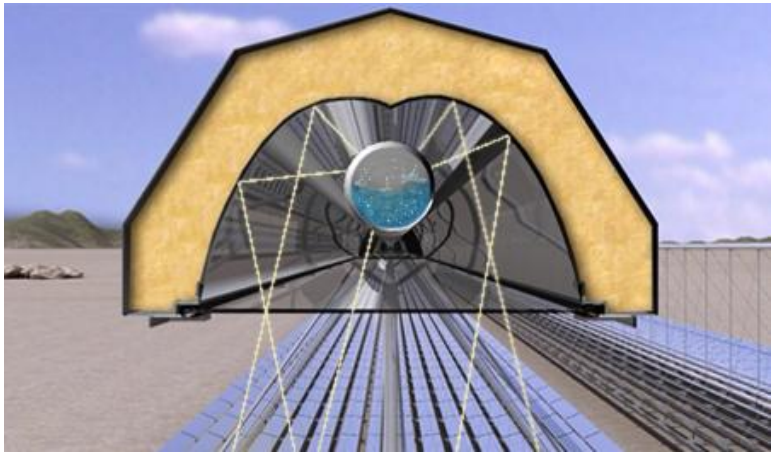
Solar
Target markets



Concentrated Solar Power
In Cooperation with Novatec Solar

Concentrated Solar Power
Technical Concept





The solar radiation is harvested and concentrated by a Fresnel reflector.

Eight rows of mirrors are continuously tracked to focus the radiation to the receiver.

Water is pumped through the receiver tube, generating steam at 100 bar with temperatures of up to 500°C.

The steam runs a turbine to generate electricity or is used for other processes.

ABB cooperates exclusively with NOVATEC Solar who has developed the most efficient CSP technology.

Concentrated Solar Power
Application

CSP Power Plants

- New Solar Thermal Power Plants
  - From 50 to 250 MWel
  - Efficient with 500°C / 100 bar
- Integrated Solar Combined Cycle
  - Solar only at day, CC at night
  - Fossil Fuel saver

CSP Process Steam

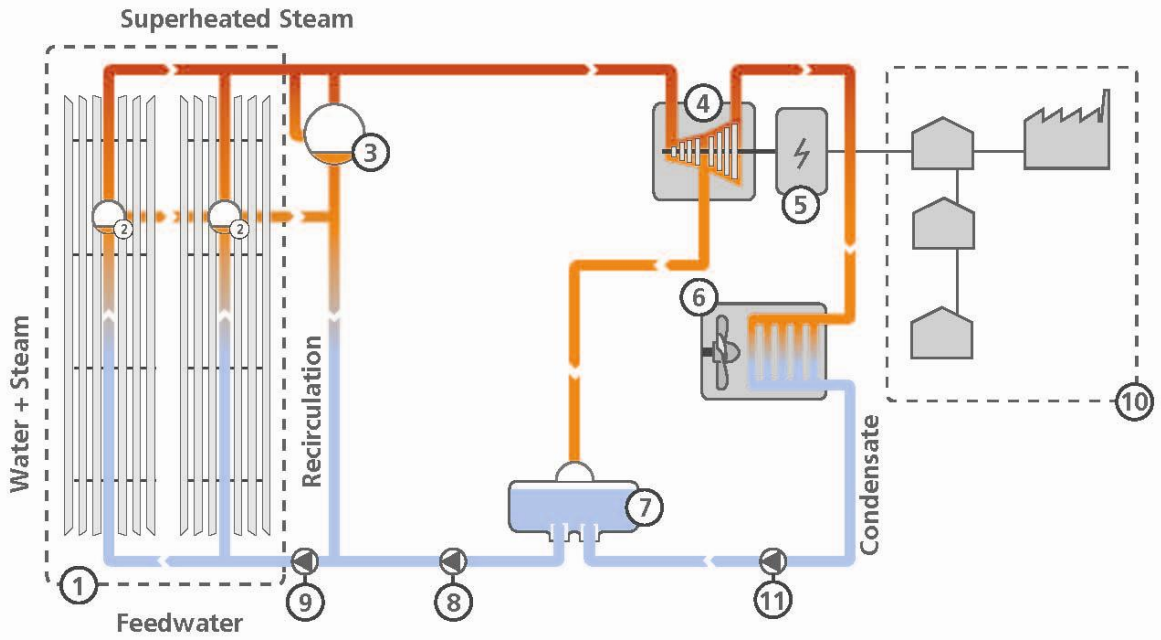
- Desalination of Seawater
- Solar Cooling
  - District Cooling Networks
  - LNG production
- Enhanced Oil Recovery
- Process Steam for Industry




CSP: Typical Set Up
ABB integrates Solar Boiler from Novatec Solar

Solar Boiler by Novatec Solar

Turn Key Power Plant by ABB



1. Solar Field
2. Steam Separator
3. Volume Balance Tank
4. Turbine
5. Generator
6. Air-Cooled Condenser
7. Deaerator/Feedwater Tank
8. Feedwater Pump
9. Recirculation Pump
10. Public Electricity Grid
11. Condensate Pump

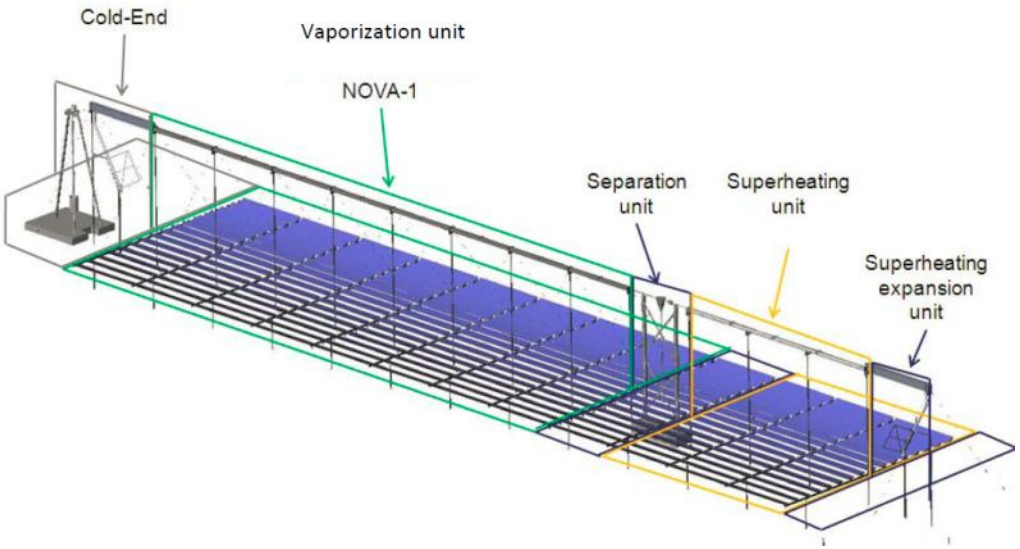
ABB offers Turn Key solutions for all CSP applications with Novatec Solar as the nominated subcontractor for the Solar Field.

ABB is a relevant strategic minority shareholder of Novatec Solar.

Highly Efficient Linear Fresnel Technology
Direct Steam Generation with Super Heater

The latest Generation of Linear Fresnel Technology in operation since August 2011:

- 700 m evaporator followed by 300 m Super Heater section
- Stable and controlled steam up to 130 bar and stable temperature up to 530° C
- Standard steam turbines as designed for combined cycle power plants allow for high efficiency of 38% which results in lower costs



Maintenance of Mirror Field
Low OPEX with flat mirrors

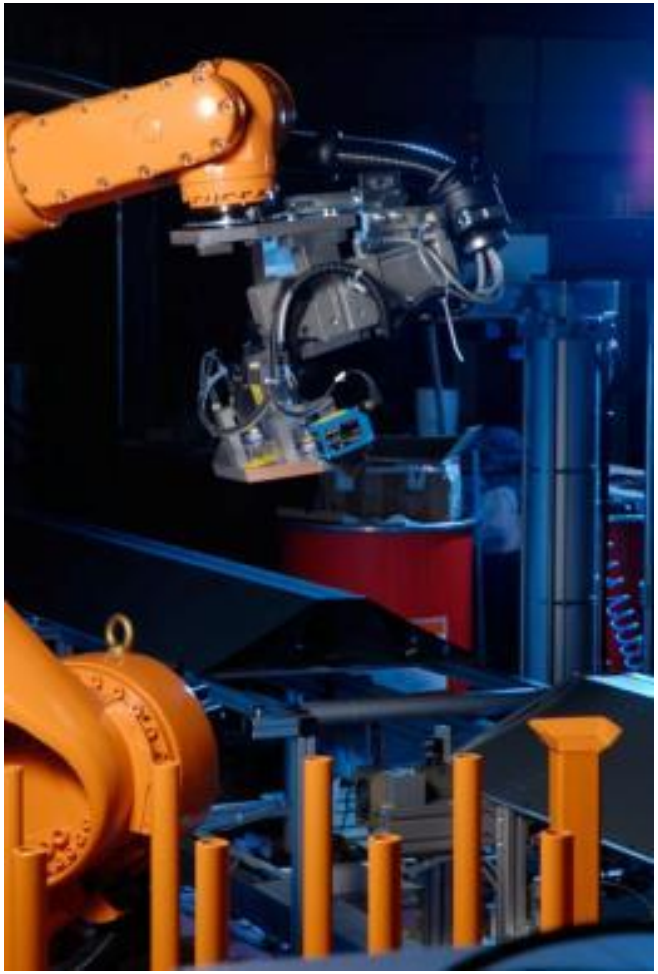
Parabolic trough

⇒ High water consumption
⇒ High labor cost

Nearly flat mirrors are cleand by a robot

⇒ Very low water consumption
⇒ Low labor costs

Automated Manufacturing System
Workshop built locally, close to site

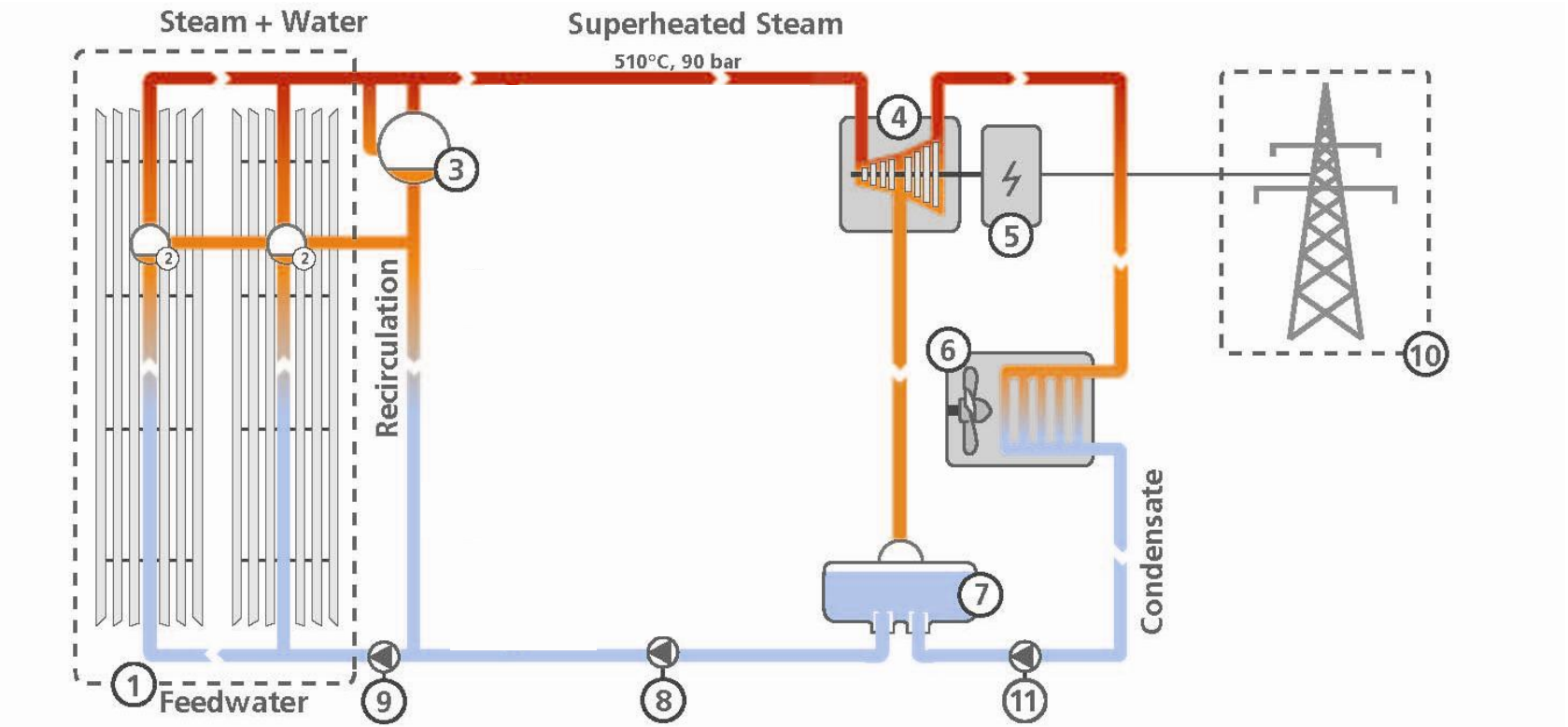


- Local fabrication of key components
- Standardized process guarantiee high level of quality
- High potential of local content supply
- High skilled job creation
- Low logistic costs
- Local value creation

Modular System
Quick and Easy Site Assembly

- Rapid site assembly due to high level of prefabrication
- Support structure based on standard components available in all markets

CSP Plant Concept Purely Solar
Highly Efficient with Superheated Steam



1. Solar Boiler
2. Steam Separator
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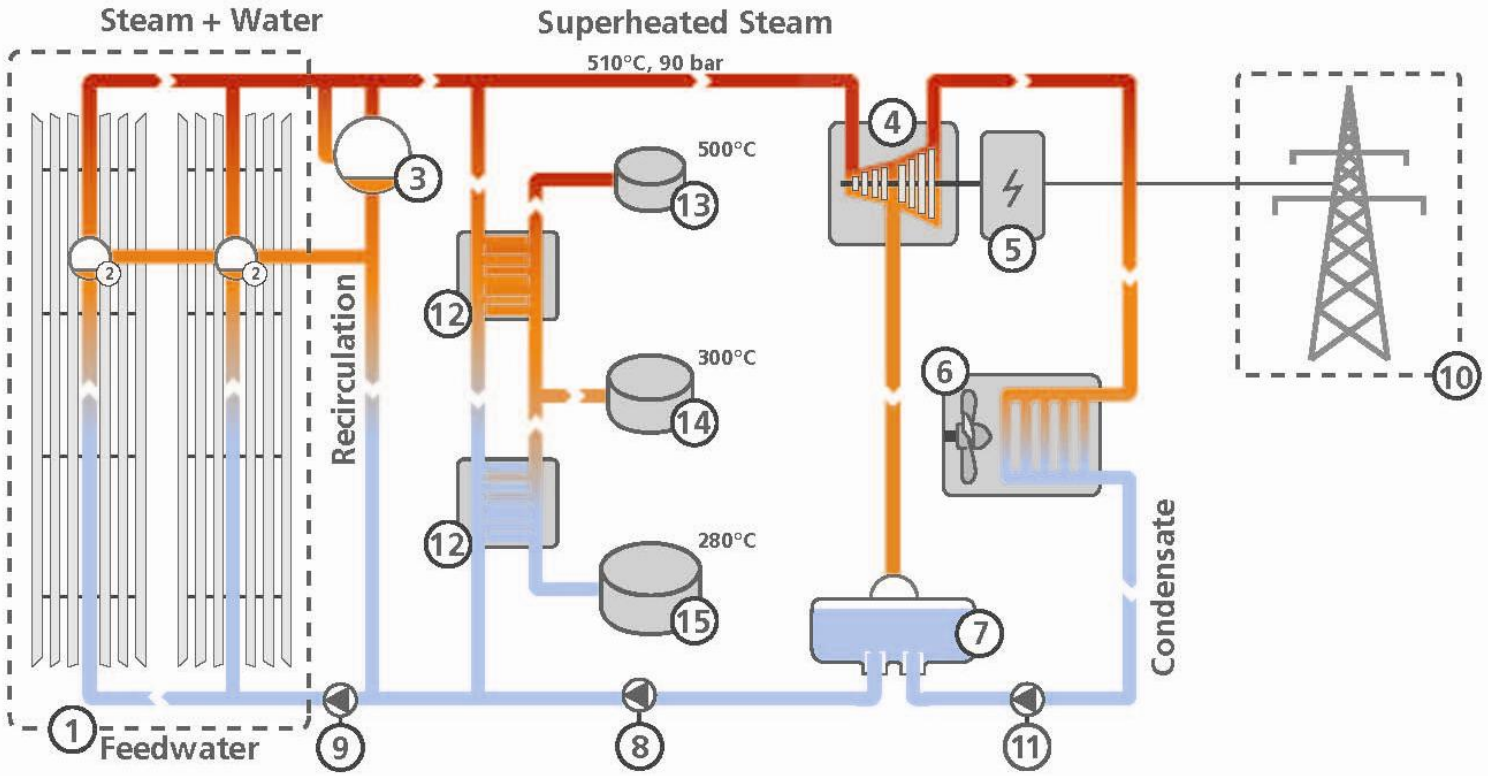
CSP Plant Concept with Thermal Storage
Three Tank Solution with Superheated Steam



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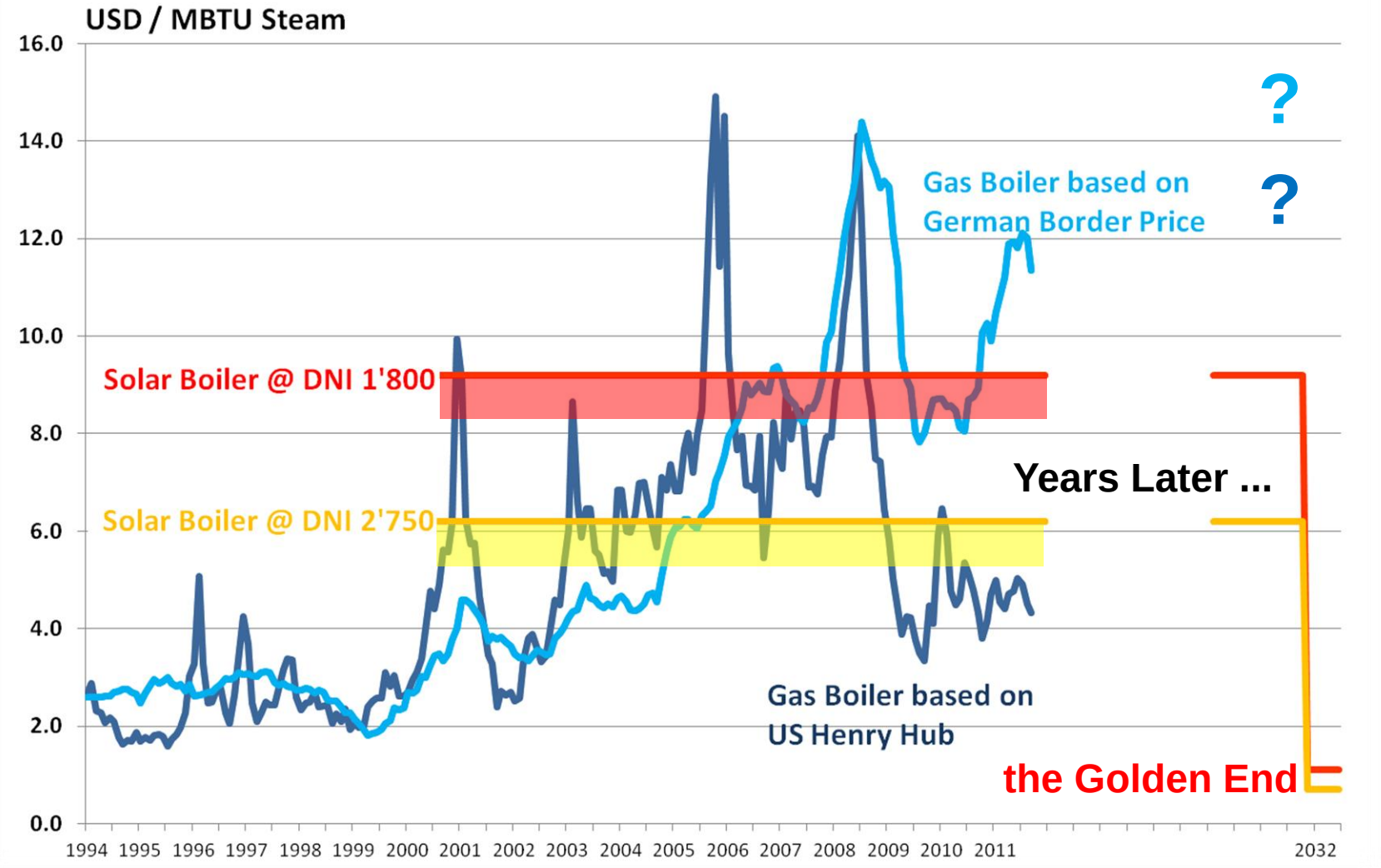
8. Feedwater Pump
9. Recirculation Pump
10. Public Electricity Grid
11. Condensate Pump
12. Salt / Water Heat Exchangers
13. Hot Salt Tank
14. Intermediate Salt Tank
15. Cold Salt Tank

CSP Steam Competitive to World Market Natural Gas
Which Technology Provides Price Certainty?



Assumptions: Gas Boiler: 90% Boiler efficiency, no tax on gas, no CO2 tax
Assumptions: Solar Boiler: Latitudes 25° , 7% WAAC, 25 years, no grants or CO2 credits considered

Comparison of CSP Technologies (1)
Lowest LCOE with ABB / Novatec

	Parabolic trough	Solar Tower	ABB Novatec
Operating temperature	390°C	Up to 540°C	Up to 520°C
Power block efficiency	36%	39%	38%
Heat losses	10 %	5-10%	5 %
Material per annual MWh thermal yield	high	Medium to high	low
Land use efficiency kWh th per m²	270	300-350	370
Storage technology	Molten salt	Molten salt	Molten salt

Comparison of CSP Technologies (2)
Lowest OPEX with ABB / Novatec

	Parabolic trough	ABB Novatec	Saving
Mirror tracking	5 kWh	1 kWh	(- 80%)
Pumping power	20 kWh	7 kWh	(- 65%)
Maintenance cost	€ 3.7	€ 2.0	(- 46%)
Water consumption for cleaning	13.4 litres	2 litres	(- 85%)

All numbers per MW per annum

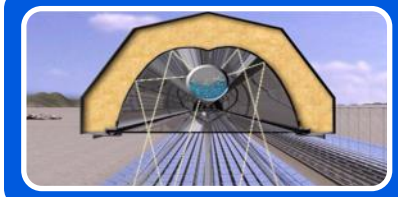
CSP: ABB offers the most effective Technology
This Makes ABB's CSP Technology Affordable

Automated Manufacturing System

- Efficient process with integrated quality control
- Local production minimize transport and logistics costs

Simple, Flat and Light Construction

- High land use efficiency (30% higher than PT)
- Low power consumption (70% lower than PT)



Direct Steam Production up to 530°C, 130 bar

- Highly efficient power block (5% higher output than PT)
- Low heat losses (50% less than PT)

Easy to Clean and Maintain

- Nearly flat mirrors cleaned by robot
- Low water consumption (85% less than PT)

PT: Parabolic Trough

CSP Reference: Puerto Errado 1, Spain
12 MWth, 1.4 Mwel in operation since spring 2010

Key Data	
EPC Contractor	**Novatec Solar**
Owner	Novatec Solar
Layout	3 rows of linear Fresnel collectors, conventional steam turbine equipment and generator, storage
Solar field length	806.40 m
Net aperture area	21,571.2 m^2
Operating temperature	Up to 500 °C
Operating pressure	Up to 65 bar
Peak thermal output	12 MW_{th}
Peak electrical output	1.4 MW_{el}
Electrical production	2.2 GWh p.a.

CSP Reference: Puerto Errado 2, Spain
150 MWth, 30 MWel in operation since Jan 2012

Key data	
EPC Contractor	**Novatec Solar**
Owners	Tubo Sol PE2 S.L. owned by 5 Swiss utilities (85%) and Novatec Solar (15%)
Layout	28 rows of linear Fresnel collectors, conventional steam turbine equipment and generator, storage
Solar field length	940.8 m
Net aperture area	302,000 m²
Operating temperature	270 °C
Operating pressure	55 bar
Peak thermal output	150 MW_{th}
Peak electrical output	30 MW_{el}
Electrical production	49 GWh/year
Fuel	Solar Only

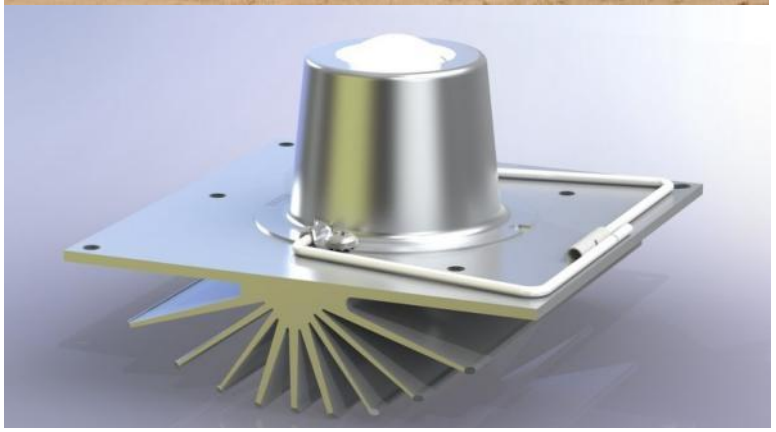
CSP Reference: Liddell, Australia
9.3 MW thermal, under hot commissioning in Jan 2012

Key data	
EPC Contractor	**Novatec Solar**
Owner	Macquarie Generation
Model	4 rows of linear Fresnel collectors, solar augmentation of a coal fired power station
Solar field length	403,2 m
Net aperture area	18,489.60 m²
Operating temperature	Up to 270°C
Operating pressure	Up to 55 bar
Peak thermal output	9.3 MW_{th}
Thermal Output per year	13,550 MWh_{th}

Concentrated Photovoltaic
In Cooperation with Greenvolts

Power and productivity
for a better world™

CPV: Concentrated Photovoltaic
Technical Concept



An accurate two-axes tracking system focus the CPV modules precisely towards the sun.

The modules concentrate the light into the receiver where it's bundled on the cell.

A very efficient triple junction solar cell converts the light with an efficiency of 38% directly into electricity. These cells are used in the aerospace industry for mission critical applications on satellites.

The receiver is designed as a heatsink and cools the cell passively.

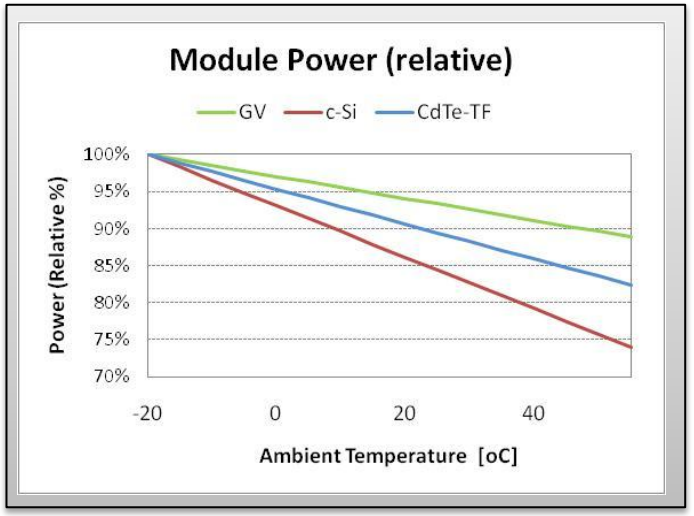
All electronics and software for each array are integrated in the System Control point. The CSP provides an output of 16 kW at 480 VAC.

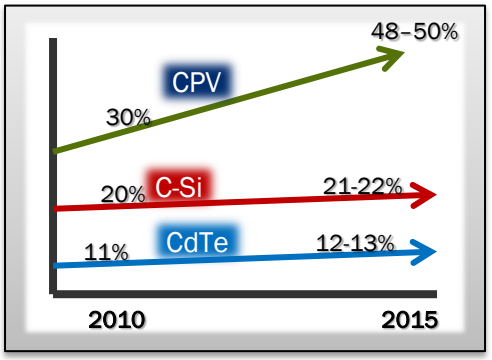
CPV: Technology Advantage
Higher Efficiency than PV or Thin Film

Today
- CPV is more efficient than c-Si and CdTe
- CPV efficiency is even more superior in hot sunny regions
- CPV energy production increases with DNI

Future
- CPV is seeing enormous efficiency gains
- Thin film is nearing the end of its efficiency gains

Cost
- Compelling cost reduction potential by CPV efficiency gains
- 1% increase in cell efficiency leads to 3% system cost savings



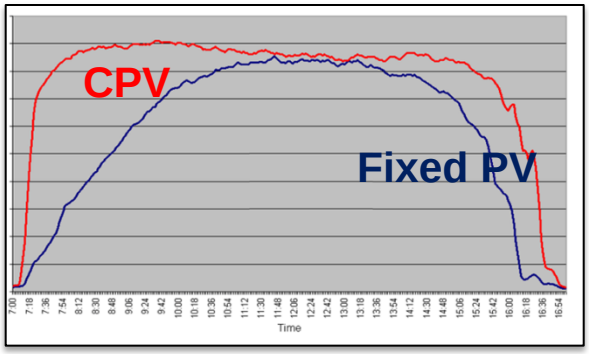


Efficiency vs. Time

Annual Energy Yield (MWh/yr)

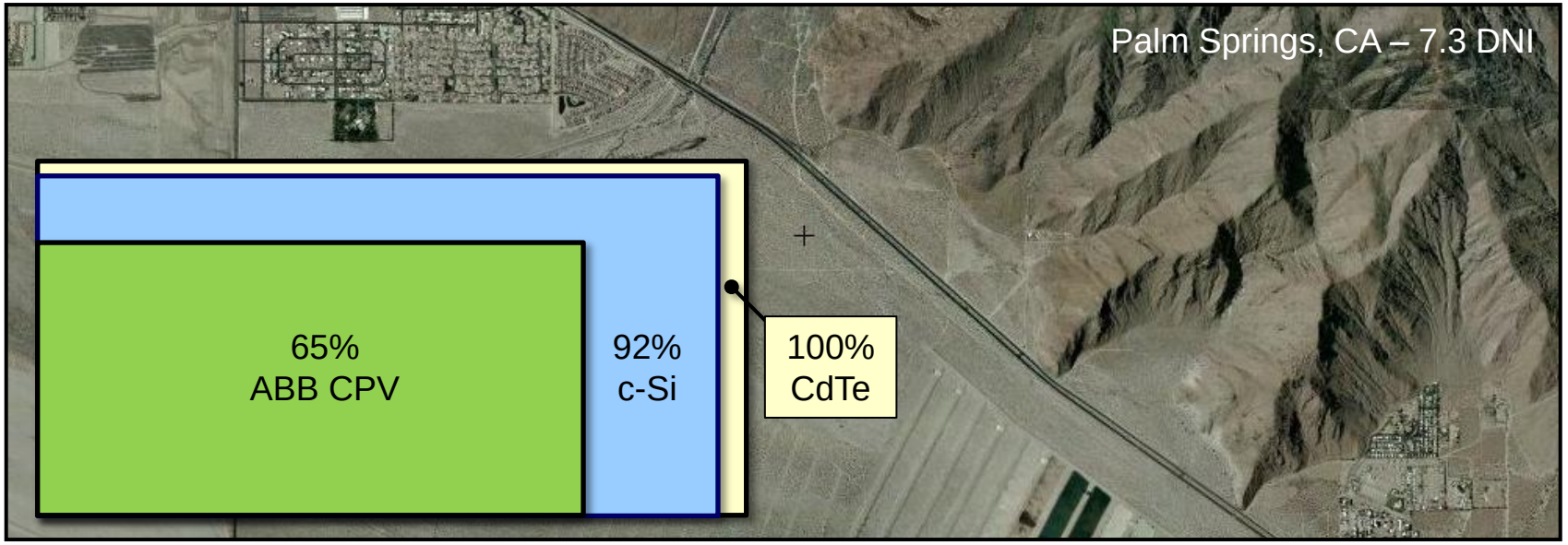
Technology	1MW Plant Creates
CdTe Fixed	1,683 (100%)
c-Si 1 Axis	2,052 (122%)
ABB	2,397 (143%)

Higher Energy Production



Two-axis tracking maximizes harvesting of the solar resource over the entire day

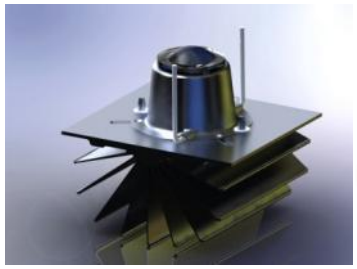
Higher Energy Yield compared to PV



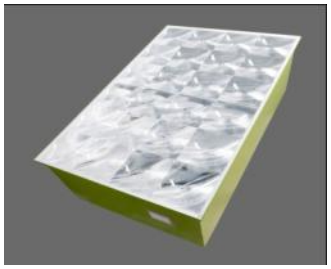
Annual Energy Yield (MWh/yr)

Technology	1MW Plant Creates	1 Acre Produces
CdTe Fixed	1,683 (100%)	406 (100%)
c-Si 1 Axis	2,052 (122%)	442 (109%)
ABB CPV	2,397 (143%)	630 (155%)

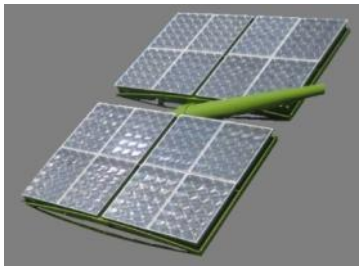
CPV: Fully Modularized and Integrated System
Optimized for high Efficiency and Reliability



x 24



x 16



x 4

Receiver: 10.4W

Module: 250W

Paddle Pair: 4kW

Array: 16kW
(primary building block)

System Control Point: SCP
(Control, Inverter, Comms, Geo)

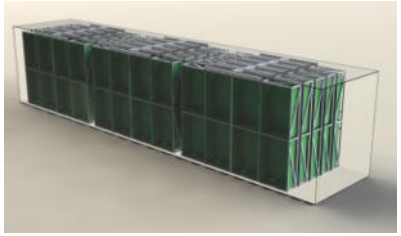
Pier
(5 per array*)

SCP
(1 per array)

Stanchion
(5 per array*)

Roll beam
(1 per array)

CPV: Shipped as Plug and Play System
Quick and easy installation out of the container



"5-packs" loaded into 40' cargo containers

Mount Stanchions

Assemble Roll Beams

Mount Roll Beams

Slide on the Paddles

Hang SCPs

Auto-Commission

CPV: Remote Operation of Power Portfolio
Sophisticated Energy Management on Mobile Device

Operating System monitors all key functions of each 16kW array

- Real time monitoring of module, tracker, and power conversion systems
- Individual IP addresses permit troubleshooting down to subsystems within each 16kW array
- All monitoring and calibration information available via secure wireless VPN
- Active weather & solar telemetry

CPV: Applications
Flexible arrangement of 16 kW arrays

CPV Power Plants

- Local low voltage integration for small capacity of 16 to 200 kW
- Industrial and agricultural integration for few hundred kW
- Utility Solar Power Station up to 50 MW

CPV Remote Power

- Agricultural pumping stations
- Relay stations for mobile networks

Benefit from Shading

- Playground shading
- Cattle shading
- Car park shading



CPV: ABB offers CPV Plants or just the System
Clients requirement defines ABB's set up

CPV Turnkey Plants

ABB acts as EPC and delivers the commissioned turnkey plant.

ABB provides full life cycle service from the early design stage, over project realization and grid connection to operation and maintenance of the plant.

CPV System

ABB trains and certifies third party EPC contractors to design, sell and construct our CPV system.

The complete CPV system is shipped in modules of 16 kW / 480 V AC to the site.

Construction and grid integration by client or third party.

CPV: Key Advantages of our Technology
Outstanding and reliable performance

Outstanding Efficiency

- Triple Junction Solar Cells offer 100% higher efficiency than Si cells
- Dual axis Tracking results in constant high yields all day long
- Well-designed passive cooling system keeps the cell cool and efficient

Completely Modularized Plug and Play System

- High quality standards being met, as modules are wired, assembled and tested at factory
- Allows quick response from factory to market
- Quick and efficient installation

Designed for Harsh Environments

- Upside-down position protects against dew, debris, soiling, hail and wind
- Wind resilience has been tested, automatic face down position in strong winds
- Multiple small units are less sensitive to wind than bigger central systems

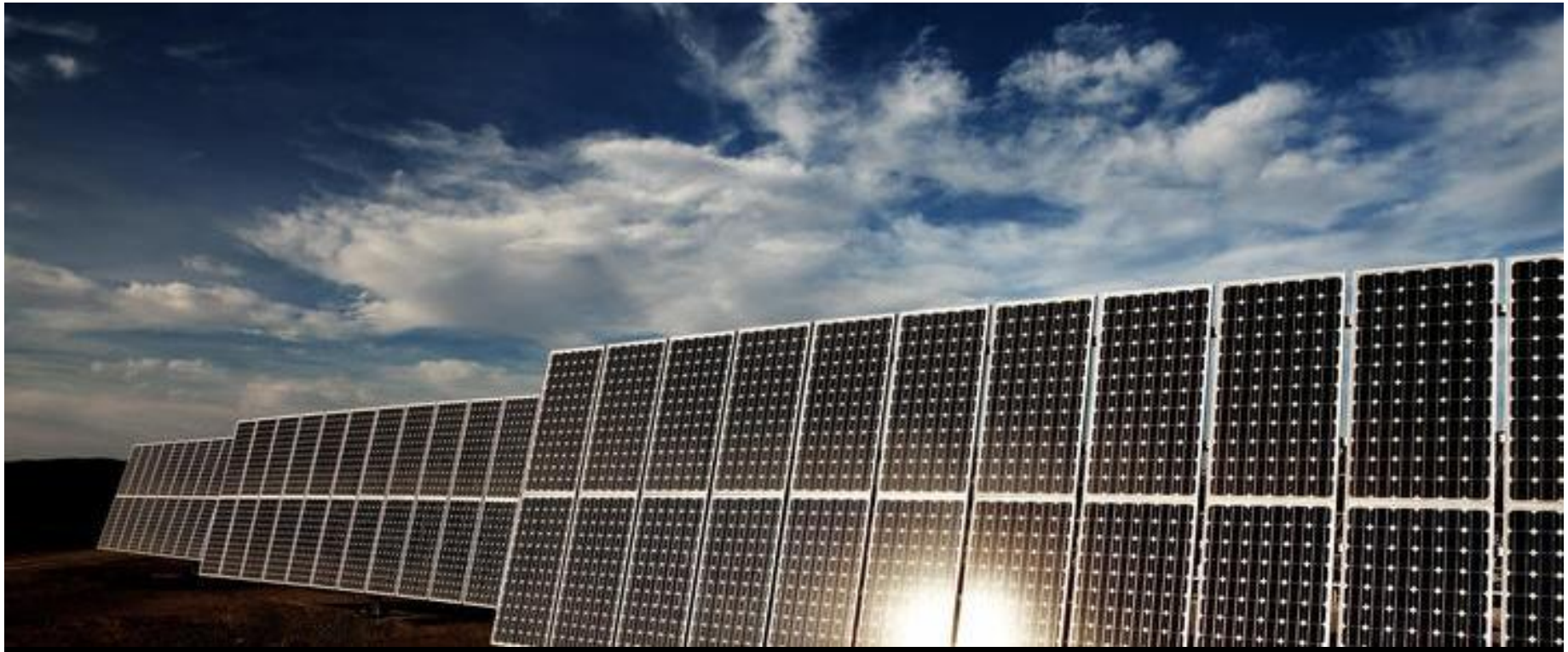
Remote Operation

- No personnel required on site
- Mobile real time monitoring and troubleshooting
- Cleaning alert indicates when maintenance would increase performance

CPV Reference: Utility Wholesale in Byron, CA
320 kW, in operation since spring 2011

CPV Reference: Insectary in Redding, CA
288 kW, in operation since Sep 2011

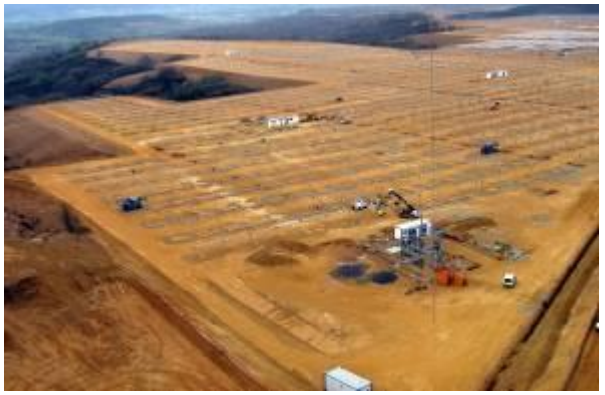
CPV Reference: Education Yuma, AZ
1 MW, in operation since Sep 2011



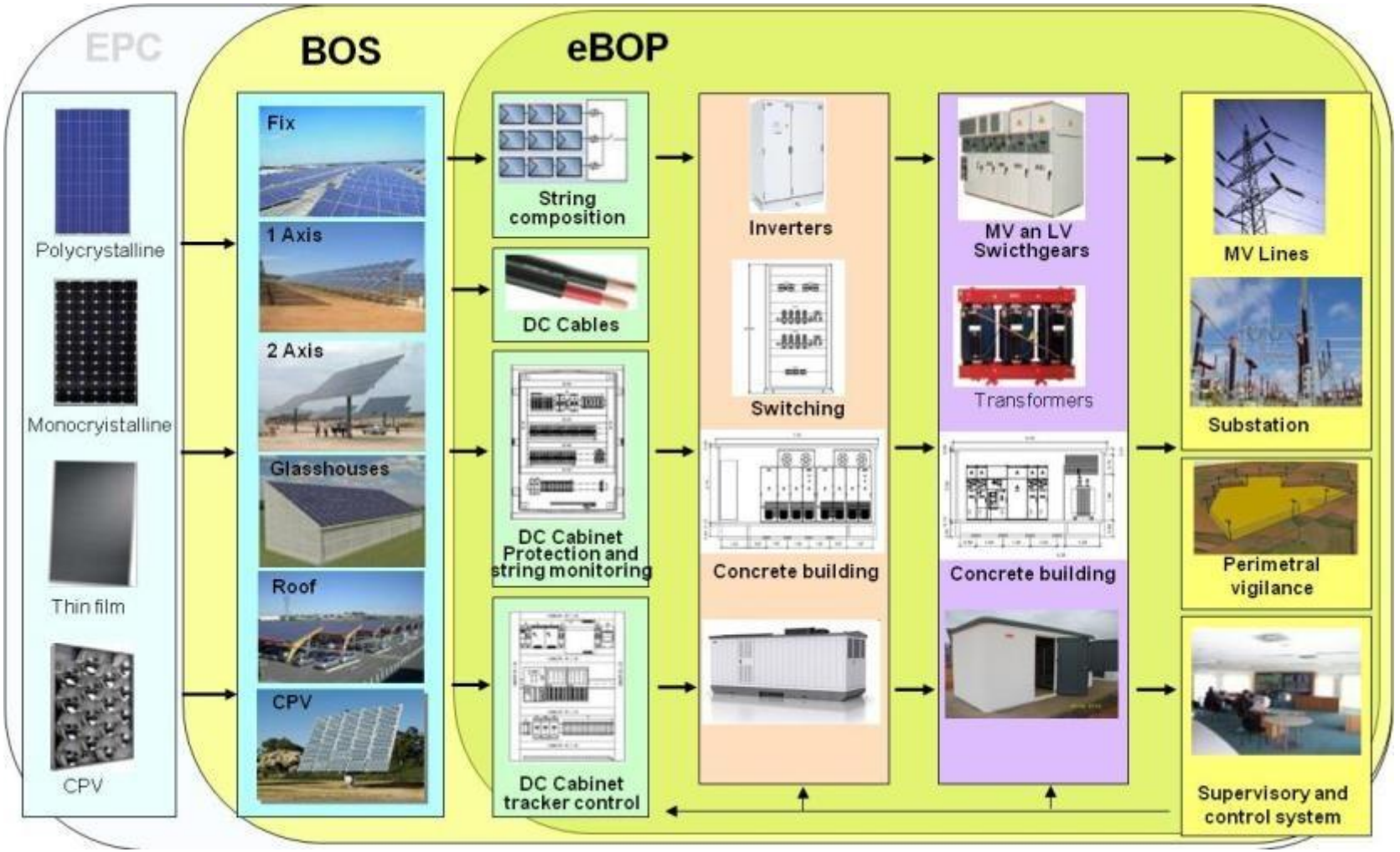
Photovoltaic Power
Integrated Solution

PV Power Plants
ABB delivers Turnkey Plant or Balance of System



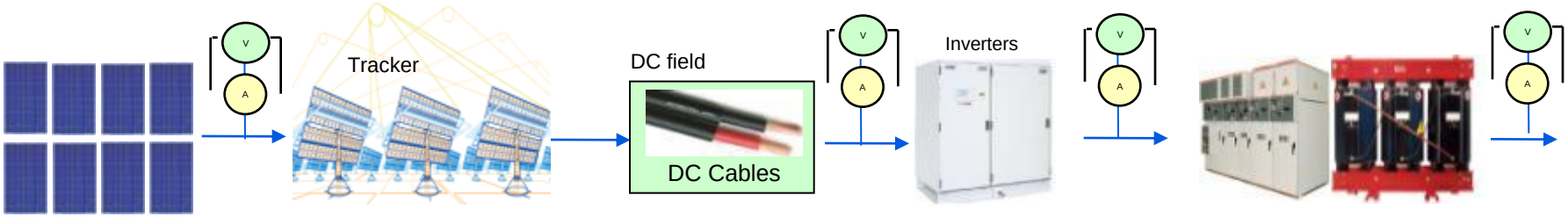



PV: Offered Scope
Clients Requirement defines ABB's scope



Panels | Trackers | DC Cabling Protectors | Inverters | Transfor-mation Center | Grid Connection

PV: ABB as turn key contractor
Integrated Solution for High Performance



Panels | **Trackers** | **DC Cabling Protectors** | **Inverters** | **Transformation Center**

Automation, Monitoring and Remote Control

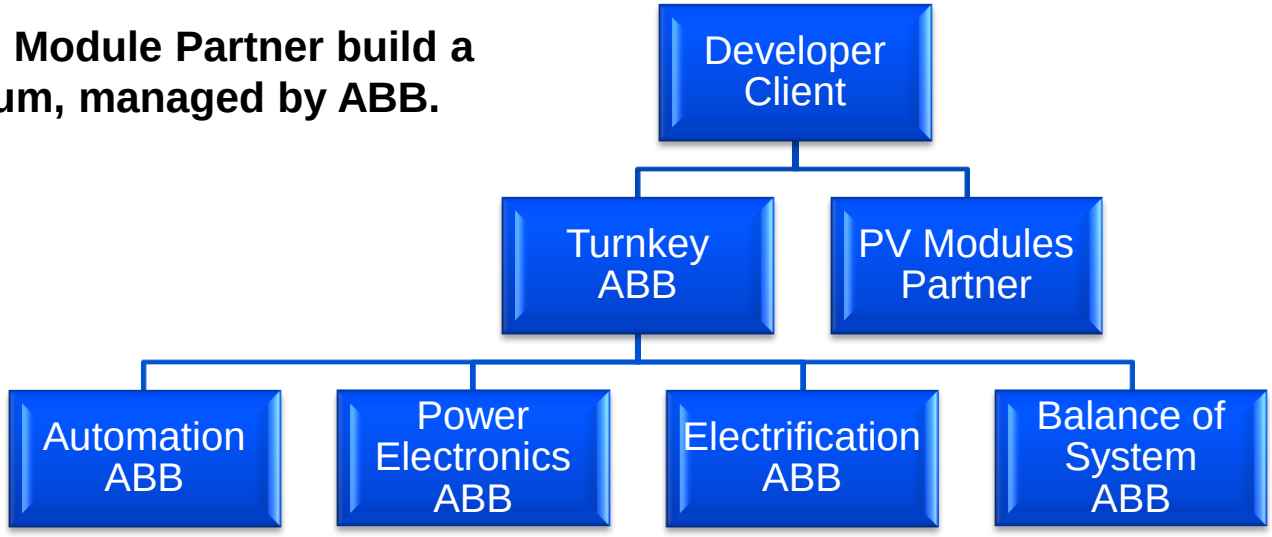
Integrated Plant Design, and Yield Calculation

Turn Key Solution
Project Management, Site Management, H&S, Quality Control

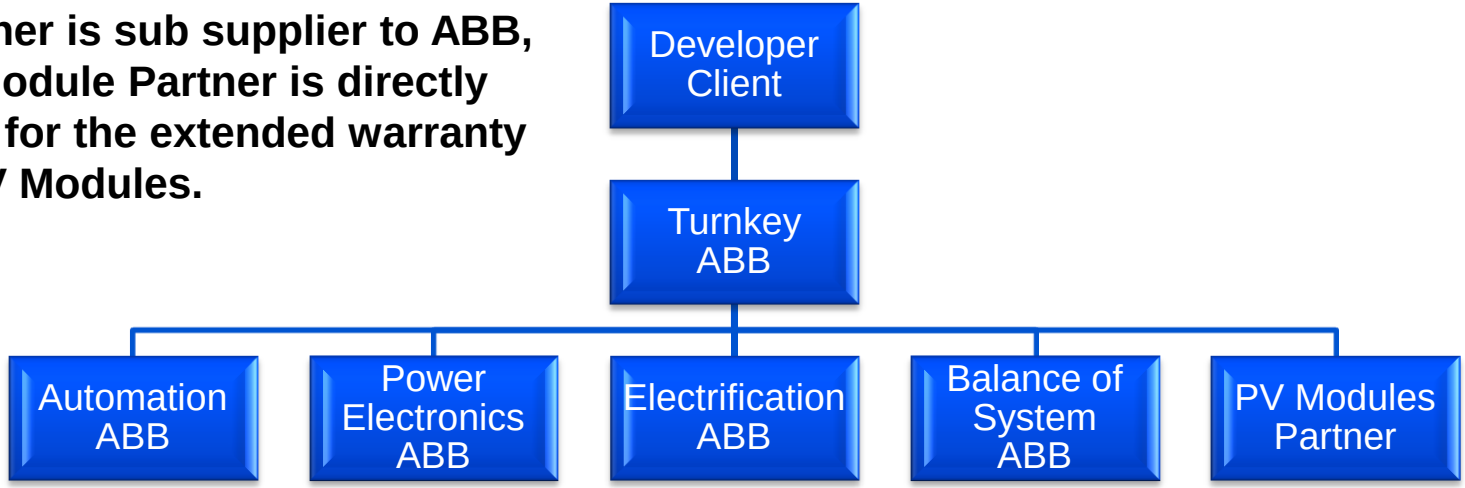
External Partner

PV: Flexible offerings according to clients requirement
ABB cooperates with Module Supplier

a) ABB and Module Partner build a consortium, managed by ABB.



b) Module Partner is sub supplier to ABB, but the PV Module Partner is directly accountable for the extended warranty period of PV Modules.



PV Reference: La Robla, Spain
13.3 MWp in operation since 2010

Customer:
GA Solar

Type of Project: ERCAM 1 axis Tracker

Turnkey 13,3 MW PV solar plant.

Year of Commissioning:
2010

Customer need

- Maximize the performance and reliability of the solar plant
- Plant in operation in 3months

ABB response

- ABB delivered the complete solar plant in consortium with a module manufacturer
- ABB applied an efficiency improvement system to maximize the overall performance of the PV solar plant
- ABB scope:
  - Supply: Substation, DC cabinets, AC cabinets, unit transformers, switchgears, equipment housing, system optimization, control and SCADA.
  - Turnkeyinstallation, ground & civil works: Inverters, trackers, PV modules, transformers and switchgears, cabinets, housing, system optimization, control, SCADA, security system, cabling, etc
- Partner scope: PV modules.

Customer benefit

- Reliable and efficient PV solar plant. Performance Ratio (PR) > 80%
- Optimized operation, control and maintenance of PV solar plant (sun tracking, system optimization, control and protection, etc.)
- La Robla produces 22.6 GWh per year – displaces 11,500 tons of greenhouse gas emissions annually
- Client kept the deadline and qualified for Spanish feed-in tariff for solar plant

PV Reference: La Sugarella, Italy
24.2 MWp in operation since 2010

Size: 24.2 MWp, 1 axis tracker

Customer: Phenix Renewable

ABB Scope: EPC

Year of commissioning:

- EPC:2010

Customer need

- First class automation and electrical systems
- Maximize plant performance and reliability

ABB response

- ABB delivered the complete solar plant in consortium with a module manufacturer
- ABB applied an efficiency improvement system to maximize the overall performance of the PV solar plant
- ABB scope:
  - Supply: Substation, DC cabinets, AC cabinets, unit transformers, switchgears, equipment housing, system optimization, control and SCADA.
  - Turnkey installation, ground & civil works: Inverters, trackers, PV modules, transformers and switchgears, cabinets, housing, system optimization, control, SCADA, security system, cabling, etc

PV Reference: Spinasanta, Italy
6 MWp, in operation since 2010

Size: 6 MWp, fix installation

Customer: Actelios Solar

ABB Scope: EPC

Year of commissioning:

- EPC:2010
- Status: Connected to the grid

Customer need

- First class automation and electrical systems
- Maximize plant performance and reliability

ABB response

- ABB delivered a complete EPC
- ABB applies an efficiency improvement system to maximize the overall performance of the PV solar plant
- ABB scope:
  - Supply: Panels, structure, inverter centers, DC & AC cabinets, transformers, switchgears, cabling, equipment housing, protection equipment, MV connection line
  - Installation: Panels, structure, inverter centers, DC & AC cabinets, transformers, switchgears, cabling, equipment housing, protection equipment, MV connection line, PV modules electrical connection

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